



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(54) Title:</b> A SYSTEM FOR PRODUCTION OF ENERGY FROM SEA WAVES		
<b>(57) Abstract</b>		
<p>A system for producing energy from sea waves consisting of a frame carrying at least two paddles units, capable of moving successively in series, when driven by progressing waves, and constituting appropriate means for transferring the successive motion of paddle units into electric energy, each of said paddles units comprising a rod, to be submerged into sea and said rod is secured on said frame with possibility for pivoting with respect thereof, the lower extremity of said rod terminates by a paddle plate and said paddles units are arranged on said frame in series so as to enable the energy of a progressing wave to be consumed successively by each paddle unit.</p>		

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# **A System for Production of Energy from Sea Waves**

## **Field of the invention**

This invention relates to a system which uses the energy of sea waves and converts it to electric energy.

## **Background of the invention**

There are different solutions for the production of energy from sea waves, for example, solutions based on wave height, wave movement, etc. The present invention utilizes both the wave length and the wave width - something which other solutions do not do.

Examples of the innovation inherent in the present invention as compared with the patents enumerated below, both from the point of view of the operating principle and structure, and from the point of view of energy considerations - allowing greater energy to be attained and produced.

1. US patent 5084630 utilizes only the width of the wave and not the length thereof. In this patent there is disclosed a system consisting of number of units provided with paddles for each section of wave width. At the bottom of each paddle there are plates. The plates are spaced laterally one from another relative to the direction of wave movement. Each paddle activated a pump. In this way, the wave power is not sufficient utilized because after the wave strikes the paddle and leaves it, it continues to advance and is not longer in contact with the paddle. Hence, The wave's power is not fully utilized. The system disclosed in US patent 5084630 utilizes variations in sea level. For this purpose it is provided with a dedicated subsystem, including a set of separate pumps. Due to this provision the whole system is complicated as it requires additional control means for coordination of the paddle disposition with the variation in sea level. Furthermore, as the disposition of the paddle is continuously changed and the paddle is not submerged deeply enough to maximally utilize available energy, it is not possible to utilize the energy of those wave components which move under the wave.

The present invention utilizes most efficiently both the length and the width of the wave in the following way:

The lower extremities of the paddles are parallel to the wave width. They are arranged one after other in such a way that from a top view, they are arranged in a series. Then, when the wave strikes the lower extremity of the first paddle it continues to move, and also strikes the other paddles, until the wave is flattened. In this way, the power of the wave is consumed in a most efficient so as to get maximum energy from the wave. The energy of the next wave coming after the first wave will be utilized in a similar way.

2. US Patent 5244359 describes a marine energy converter system based on utilization of differences in sea level which it converts into linear movement only of piston 21

which moves within its casing 17. The casing 17 is rigidly connected with pole 3 which is anchored at the bottom of the sea. The above converter can only exploit linear movement, and does not make it possible to exploit the dynamic energy of the sea waves. The above converter is equipped with a floating system piston. The piston is connected to a float 41 and this enables the linear movement of the piston within the piston casing. As a result the piston, which rises within its casing by virtue of the rising level of water, requires very little force to rise. However, since energy is always a product of force multiplied by distance, the resultant energy is very small as a consequence of the small amount of force exerted.

The present invention, however, is based on a different principle, i.e., the exploitation of the dynamic energy of sea waves, which gives rise to pivotal movement of the paddles rather than their elevation. The pivotal movement is subsequently converted into linear movement of the piston by means of a crank shaft mechanism 32, 40. The piston rises within the casing with relatively great force and the energy produced is thus greater.

Thanks to the structure of the system according to the present invention, it is possible to utilize wave energy in the most efficient way, i.e., exploit the dynamic energy of the wave regardless of the height of the wave itself.

Both from the point of view of the present invention's operating principle and from the point of view of its particular structure, the US 5244359 energy converter is not similar to the present invention.

3. US Patent 4843249 describes a hydro-electric system which utilizes the movement of the waves and converts them into circular movement. Said system includes a turbine 22 whose vanes are moved by the moving wave. The turbine wheel is connected to equipment for the generation of electrical energy.

The present invention, by comparison, does not convey circular energy, but rather utilizes the axial movement of the paddles to move the piston in a linear motion.

As in the previous case, the above US patent does not void the innovation or the inventive innovation of the present invention, neither in principle nor from the point of view of the structure of the above - described patent.

It may also be noted, that the utilization wave energy in order to create circular energy along, is inferior to the creation of linear motion, on the following counts:

In order to achieve better than 90% utilization, for example, a pump activated through circular energy must rotate at speeds of 500-5000 rpm. Below 500 rpm, the efficiency rate is abruptly reduced to about 40%. In order to attain such high speeds, when the wave movement is relatively low, it is necessary to provide additional transmission by means of a few pairs of cog-wheels, thus creating losses in the system. Moreover, if we introduce a number of pairs of cog-wheels, then the total efficiency of the system is reduced, and the energy produced is thus far lower. The cost of the system too, is increased through the provision of many pairs of additional cog-wheels.

However, when the piston moves in a linear motion, the immediate efficiency of the system is at least 90% and a linear pump or linear motor are not limited by any constraints.

4. US Patent 53311064 describes a system for generating energy from the movement of sea waves, based on a similar principle to that of the above described hydro-electric system, i.e., the use of a turbine which is rotated by the flow of water. The circular movement is conveyed to the energy generating mechanism by means of a transmission mechanism.

All the above given explanations regarding the hydro-electric system according to US patent No. 4843249 are also valid in this case, both as regards circular motion versus linear motion and the differing structure.

### **Brief description of the drawings**

- Fig 1. is a schematic view of the invention, showing different positions of a paddle driven by a wave.
- Fig 2,3. schematically illustrate the means of transmission used to transfer the pivotal movement of a paddle rod into the reciprocating movement of a piston rod.
- Fig 4. shows 3 different positions of a piston within a pump.
- Fig 5. shows a side view of the system in accordance with the present invention.
- Fig 6. is a top view of the system in accordance with the present invention.
- Fig 7 shows how a system in accordance with the present invention is connected with appropriate means for transforming paddle motion into electric energy.
- Fig 8. shows how each paddle unit is provided with two hydraulic cylinders actuated by the paddle rods of each unit.
- Fig 9 shows additional embodiment of the present invention.

### **Detailed description of the preferred embodiment**

With reference to fig 1, the system in accordance with the present invention comprises a support structure 10 consisting of legs 12 carrying an upper frame 14. The legs are anchored in the sea floor.

On the upper frame there are mounted at least two paddle units, which will be described in more detail later on. Each paddle unit comprises a paddle rod 20 connected to a housing 24. Within the housing there is mounted an axle 22, which is rigidly secured to the upper frame.

Each paddle unit comprises a paddle rod 20 rigidly connected to the housing 24. The housing is mounted around an axle 22, secured to the upper frame 14. A rotational movement of the housing with respect to the axle is accomplished by virtue of a pivotal movement of the paddle rod 20, driven by a wave.

The lower extremity of the paddle rod 20 is terminated by a paddle plate 28, which encounters the wave and is driven thereby. The height of the legs 12 and also the



distance between the upper frame 14 and the sea level SL is chosen in such a manner that the main portion of the paddle plate 28 is submerged under sea level., while the 4

upper part of the paddle plate 28 thereof is situated above to the sea level SL as can be seen in fig 5. By virtue of this disposition it is possible to utilize the energy of the wave approaching the paddle plate not only below sea level but also above.

In contrast to the known system described in US 5084630, where the energy of a wave broken by the paddle is not consumed fully, as the wave continues to move freely, in the present invention all paddle units are arranged in series. By virtue of this arrangement the energy of a wave after it has been broken by a leading paddle unit will be consumed by a successive paddle unit.

Due to this arrangement the energy of approaching waves is consumed in most efficient way.

With reference to fig 1 one can see different stages of a pivotal moving paddle unit driven by a wave entering the system.

The other important feature of the system in accordance with the present invention is the fixed disposition of paddle plate 28 with respect to the sea floor.

With reference to fig 5 the distance between the lower extremity of paddle plate 28 and the sea floor is designed by D.

It has been found empirically that keeping this distance constant helps utilize the energy of a wave approaching the paddle plate, in the most efficient way.

In practice for a sea floor depth of 3m and a wave height of 1m ( defined as: 0.5m above sea level and 0.5m below sea level ) the following paddle dimensions may be recommended: the length of the paddle rod can be 5.5m, the height of the paddle plate can be 0.5m-3m, the width of the paddle plate can be 2m, and the distance D can be 1m. If the dimensions are given as above, the distance between two paddle units belonging to the same system should be 1m - 1.5m.

Now with reference to figs 2,3 it will explained how the pivotal movement of the paddle rods, driven by sea waves is transferred into energy:

As shown the housing is rigidly connected with an intermediate rod, which terminates with part 34. The part is provided with an auxiliary short axle 36 carrying a bearing 38. The outside ring of the bearing is secured within a piston rod 40.

It can be readily understood that the combination of elements 32 - 40 constitutes a common crank shaft mechanism, which the pivotal movement of the transforms paddle rod 20 into a linear reciprocating motion of the piston rod 40.

On the upper extremity of piston rod 40 there is a secured piston 42, constituting port of hydraulic cylinder 44, provided with hydraulic fluid ports 46,48 and appropriate valves.

It is not shown specifically, but should be understood, that the hydraulic cylinder is connected with an appropriate means for utilizing the flow of hydraulic fluid via the fluid ports.

In operations, the sea waves successively approach the first paddle unit and then the second paddle unit and thus cause pivotal movement of each paddle rod.

Each paddle unit is provided with a dedicated crank shaft mechanism transforming this movement into a linear motion of the corresponding piston supplying hydraulic fluid from the corresponding cylinders HC1, HC2 to an accumulator A. Hydraulic fluid exits the accumulator and actuates an hydraulic engine, which drives a generator.

With reference to fig 7 it is shown how system S1, in accordance with the present invention, is connected by such means. The system includes two paddle units PU1,

and PU2, arranged successively in series and each unit is provided with a dedicated hydraulic cylinder HC1, HC2. Both cylinders are connected in parallel to accumulator A, which is connected to hydraulic engine HE. The hydraulic engine drives generator G, which produces electrical energy.

Both extremities of the piston rod are connected to the hydraulic cylinder. By virtue of this arrangement it is possible to increase the amount of power produced by the same paddle unit. With reference to fig 8 it is shown how each of the paddle units PU1, PU2 provided with two hydraulic cylinders HC1, HC2 and HC3, HC4 respectively, are actuated by the paddle rods of each unit. All hydraulic cylinders are connected to accumulator A in parallel as in the previous embodiment.

With reference to Fig 9 there is shown additional embodiment of the present invention. In this embodiment the frame is provided with adjustment means permitting slight pivotal movement of the frame within the surface of the sea level. By virtue of this pivotal movement the paddle plates can always be oriented perpendicularly to the direction of propagating wave.

In this embodiment the system is provided with a buoy 50 floating in front of the system and capable to transmit there to electronic signal advising about direction of approaching wave AW. The system is provided an appropriate receiver ( not shown ) which generates appropriate electronic signal effecting adjustment movement of the frame by virtue of adjustment means 52, which enable slight swiveling of the frame along arrow A in clockwise or against clockwise direction.

The system is above the sea level SL and mounted on columns 51 which are anchored to the sea floor. The frame carries on its opposite sides adjustment to columns 51, the adjustment means 52 which comprise 2 series of wheels rotatable by appropriate motor

( not shown ) so as to provide for swiveling of the frame with respect to upper parts of columns. The motor is controlled by electronic signal generated by buoy 50 and corresponding to the current direction of approaching wave AW.

It can be realized that by virtue of this signal it is possible to effect the motor and to adjust the disposition of the frame with respect to the approaching wave. In practice this adjustment should be effected so as to ensure that paddle plates carried by the frame are perpendicular to the direction of movement of the approaching wave.

In order to provide the frame with sufficient rigidity, it is formed with reinforcing elements 53.

The features of the present invention described in the foregoing description, in the following claims, and in the accompanying drawings, may both separately and in any combination thereof be material for realizing the invention in diverse forms thereof.



**claims**

1. A system for producing energy from sea waves consisting of a frame carrying at least two paddles units, capable moving successively in series, when driven by progressing waves, and constituting appropriate means for transferring the successive motion of paddle units into electric energy, each of said paddles units comprising a rod, to be submerged into sea and said rod is secured on said frame with possibility for pivoting with respect thereof, the lower extremity of said rod terminates by a paddle plate and said paddles units are arranged on said frame in series so as to enable the energy of a progressing wave to be consumed successively by each paddle unit.
2. A system as defined in claim 1, in which said paddles units are secured on said frame in such a manner, that the distance between the lower extremities of a paddle and the sea floor is kept invariant.
3. A system, as defined in claim 1, in which said means for transferring reciprocative motion of paddle units into electric energy, comprises a crank shaft mechanism driven by a paddle unit and a piston actuated by said crank shaft mechanism.
4. A system, as defined in claim 3, in which each paddle unit is provided with a dedicated crank shaft mechanism driven by said unit and with at least one piston actuated by said crank shaft mechanism.
5. A system as defined in claim 1 comprising adjustment means enabling pivotal movement of said frame on the sea surface so as to direct said paddle plates substantially perpendicularly with respect to direction of movement of approaching wave.

**AMENDED CLAIMS**

[received by the International Bureau on 02 February 2000 (02.02.00);  
original claims 1,5 replaced by amended claims (1 page)]

1 A system for producing energy from sea waves, said system comprising a frame carrying at least two paddle units, said paddle units are movable by progressive waves, each of said paddle unit comprising a rod, to be submerged into sea and said rod is secured on the frame with possibility for pivoting with respect thereof, the lower extremity of the rod terminating by a paddle plate, said paddle units reside on the frame in such a manner that the adjacent paddle plates are arranged in series and accordingly accept and consume the energy of progressive wave successively, wherein each of said paddle unit is provided with a dedicated transfer means for converting reciprocate pivoting motion of the paddle unit into electric energy, said transfer means comprising a crankshaft mechanism mounted on the frame with possibility to be driven by the rod and with a piston actuatable by the crankshaft mechanism.

2. The system as defined in claim 1, in which said paddle units are secured on the frame in such a manner that the distance between the lower extremities of paddle plates and the sea floor is kept substantially invariant.

3. The system as defined in claim 2, comprising adjustment means for adjusting the disposition of the paddle plates substantially perpendicularly to the direction of movement of progressive waves.

**STATEMENT UNDER PCT ARTICLE 19**

Claim 1 (the main claim) of the above application has been amended to incorporate the features referring to crankshaft mechanism and a piston and also to providing each of the paddle units with a dedicated crankshaft mechanism.

The main claim has been also amended to emphasize the arrangement of the adjacent paddles in series and not in staggered disposition as it is in US 5084,630 or as it is in GB 384,603.

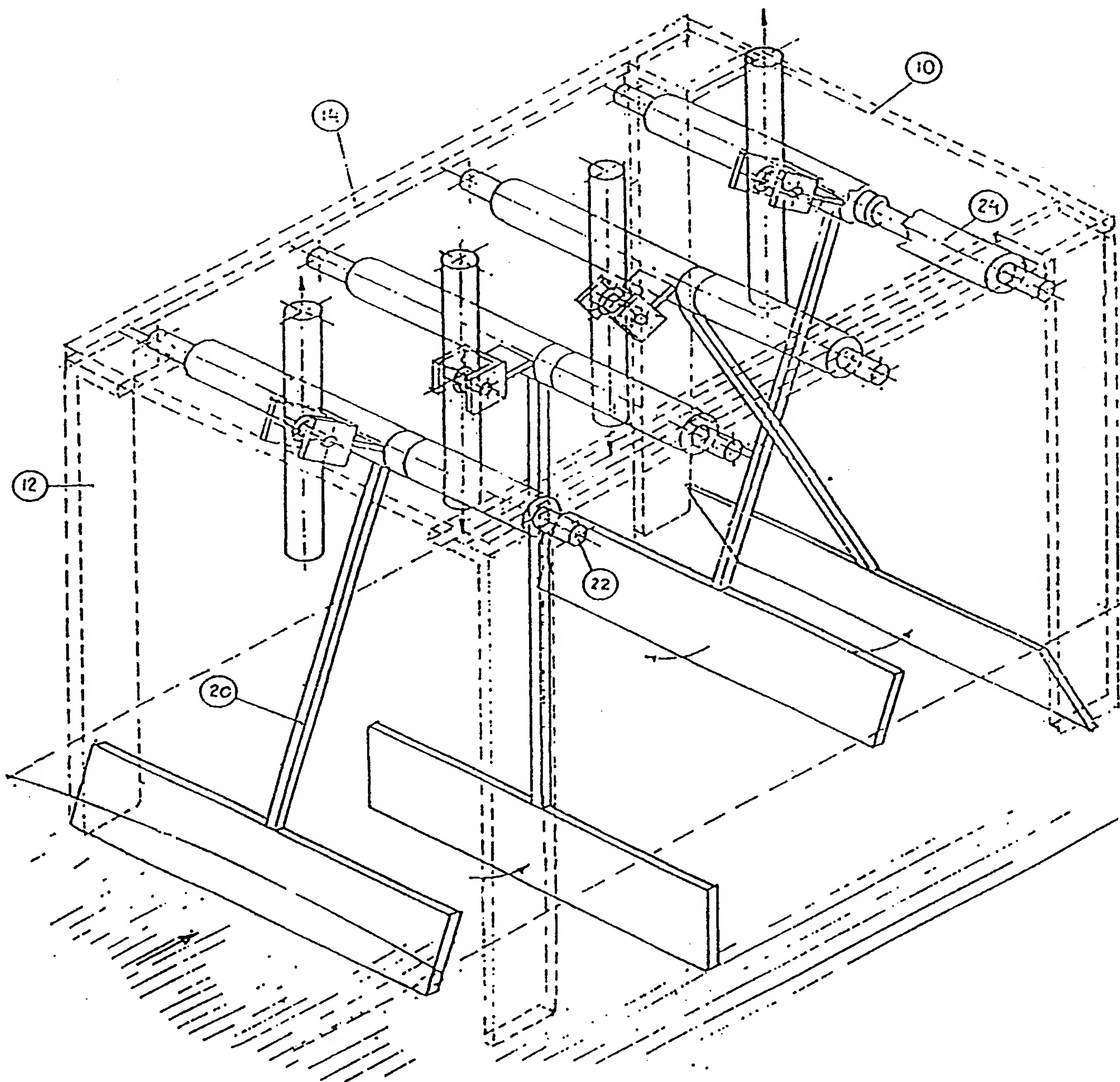
The features referring to the introduced amendments can be found in the specification on pp.4, 5, figs.1, 2, 3, 4.

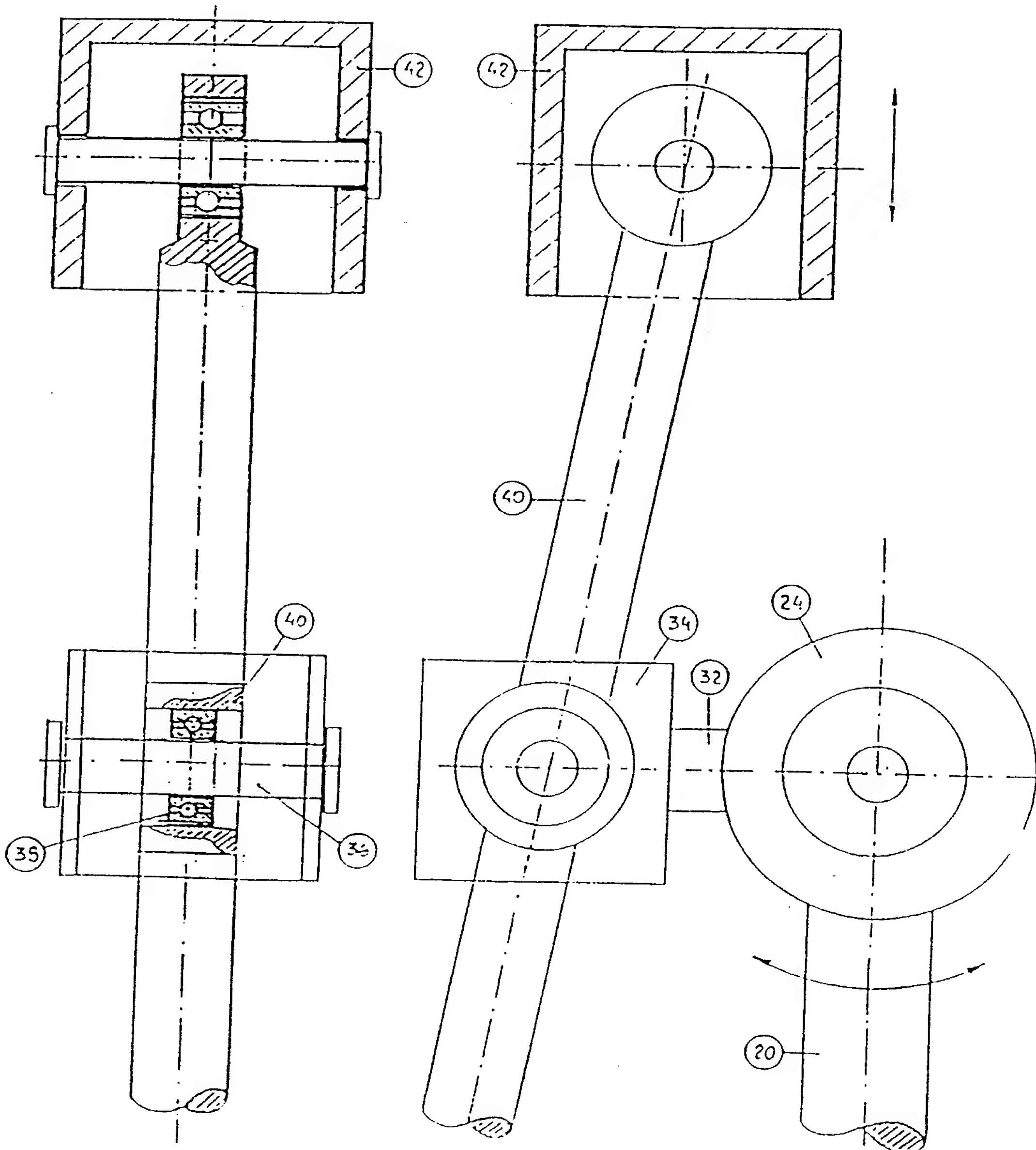
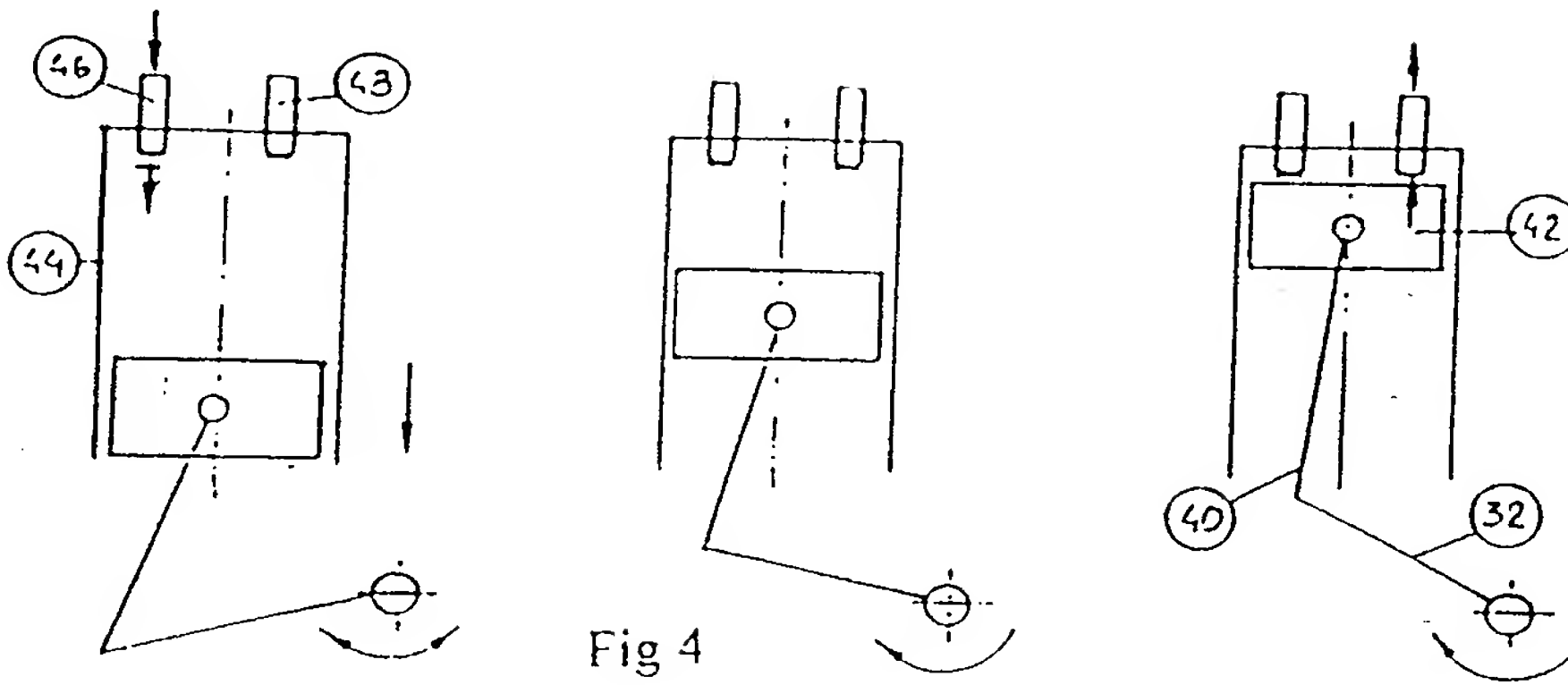
The introduced amendments do not go beyond the disclosure in the above referred-to application as filed, they do not introduce any new matter and there is no impact on the description and the drawings.

Neither of the references cited in the search report comprises combination of the features as defined in the amended main claim and therefore the Applicant respectfully requests reconsideration of the characterization of the references during Chapter II examination.

With sincere regards,

Fig 1









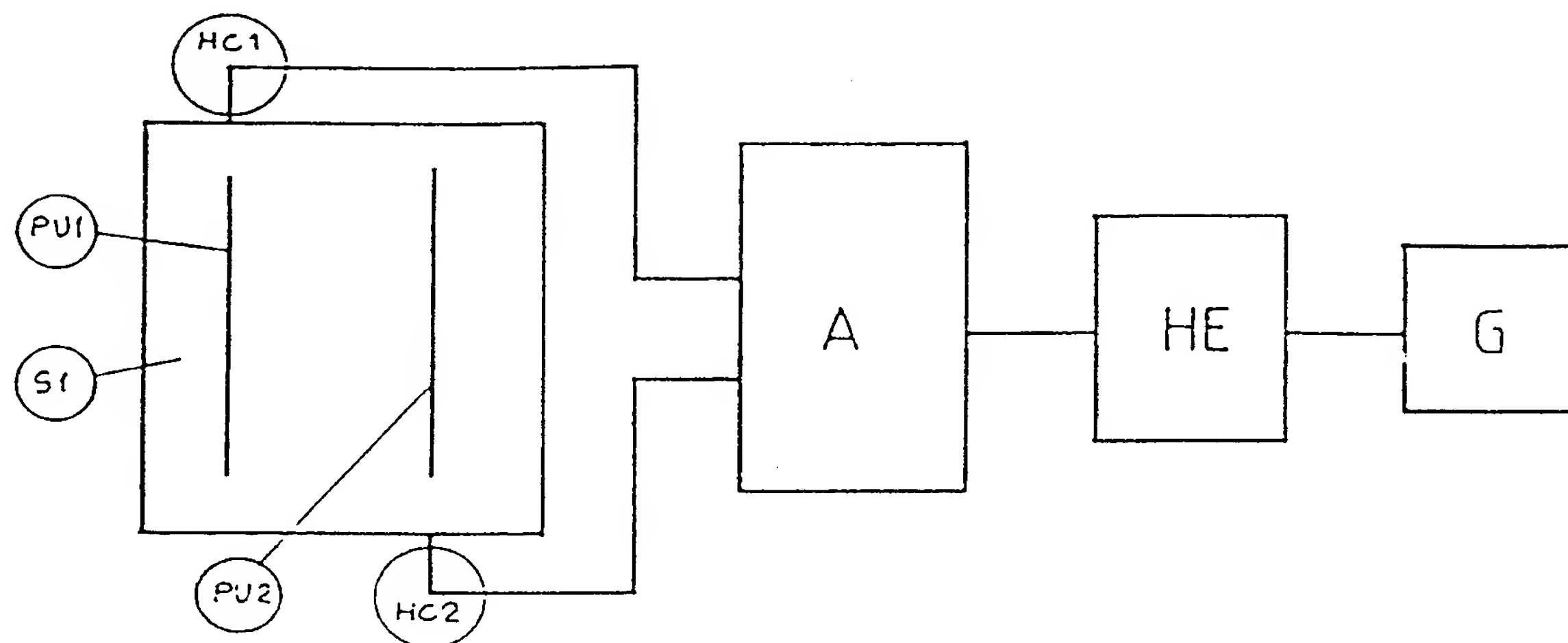


Fig 7

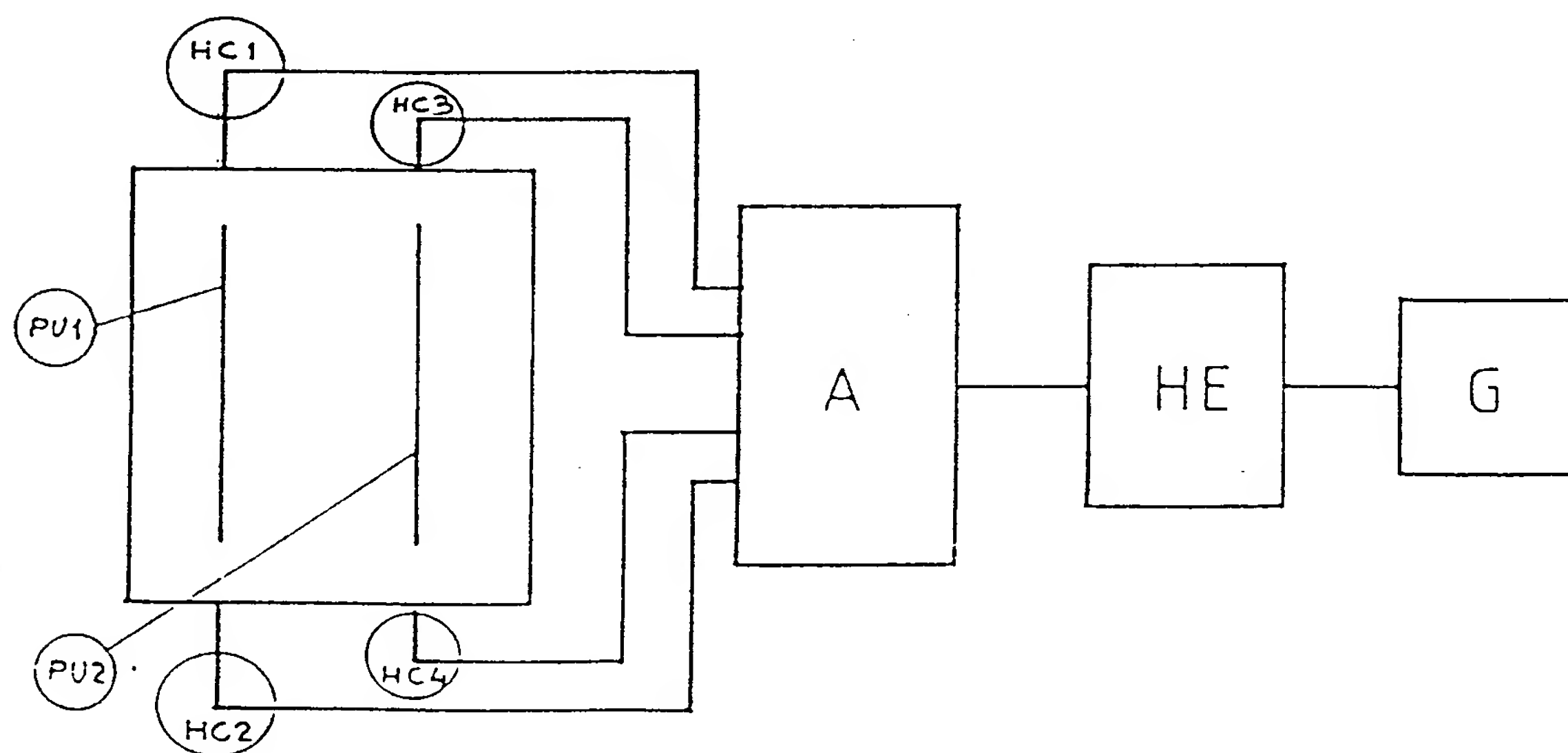


Fig 8

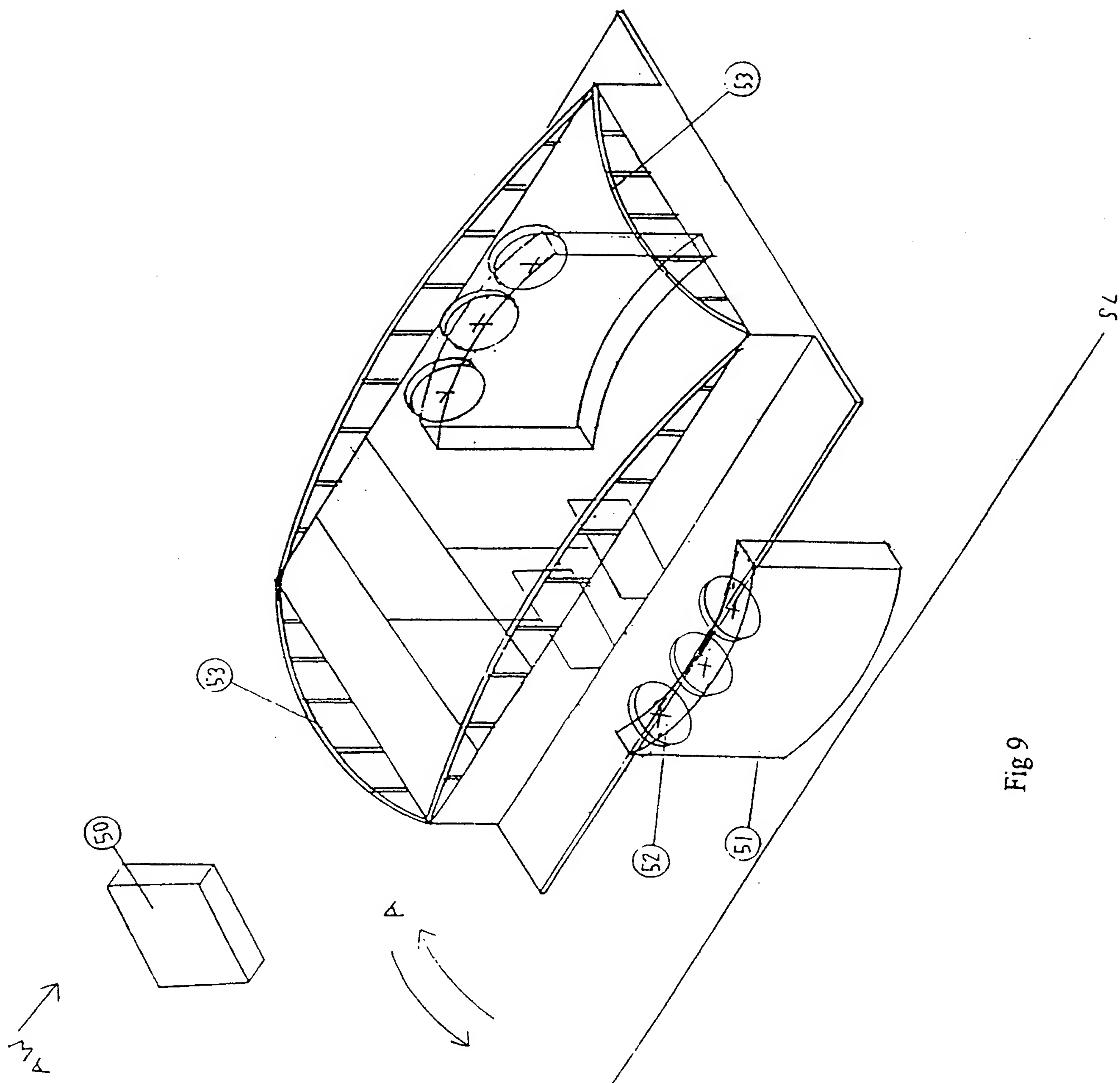


Fig 9

## INTERNATIONAL SEARCH REPORT

national Application No  
PCT/IL 99/00258A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 F03B13/18

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 384 603 A (M.J.ABIGERAIGE) 8 December 1932 (1932-12-08) page 1, line 20 - line 29 page 1, line 83 - line 101	1,2
Y	figures	3-5
Y	US 5 084 630 A (AZIMI HOSSEIN) 28 January 1992 (1992-01-28) cited in the application abstract column 2, line 31 - line 40; figures 3,4	3,4
Y	FR 2 501 795 A (BERGER MICHEL) 17 September 1982 (1982-09-17) page 3, line 16 - line 17; figure 1	5
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

26 November 1999

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Fax: (+31-70) 340-3018

Authorized officer

Criado Jimenez, F

# INTERNATIONAL SEARCH REPORT

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 246 820 A (BALFOUR THOMAS) 12 February 1992 (1992-02-12) the whole document	1
A	US 4 384 456 A (BOROS LADISLAV J) 24 May 1983 (1983-05-24) abstract; figure 2	2



# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IL 99/00258

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 384603 A		NONE	
US 5084630 A	28-01-1992	GB 2230300 A, B NO 175325 B	17-10-1990 20-06-1994
FR 2501795 A	17-09-1982	NONE	
GB 2246820 A	12-02-1992	NONE	
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